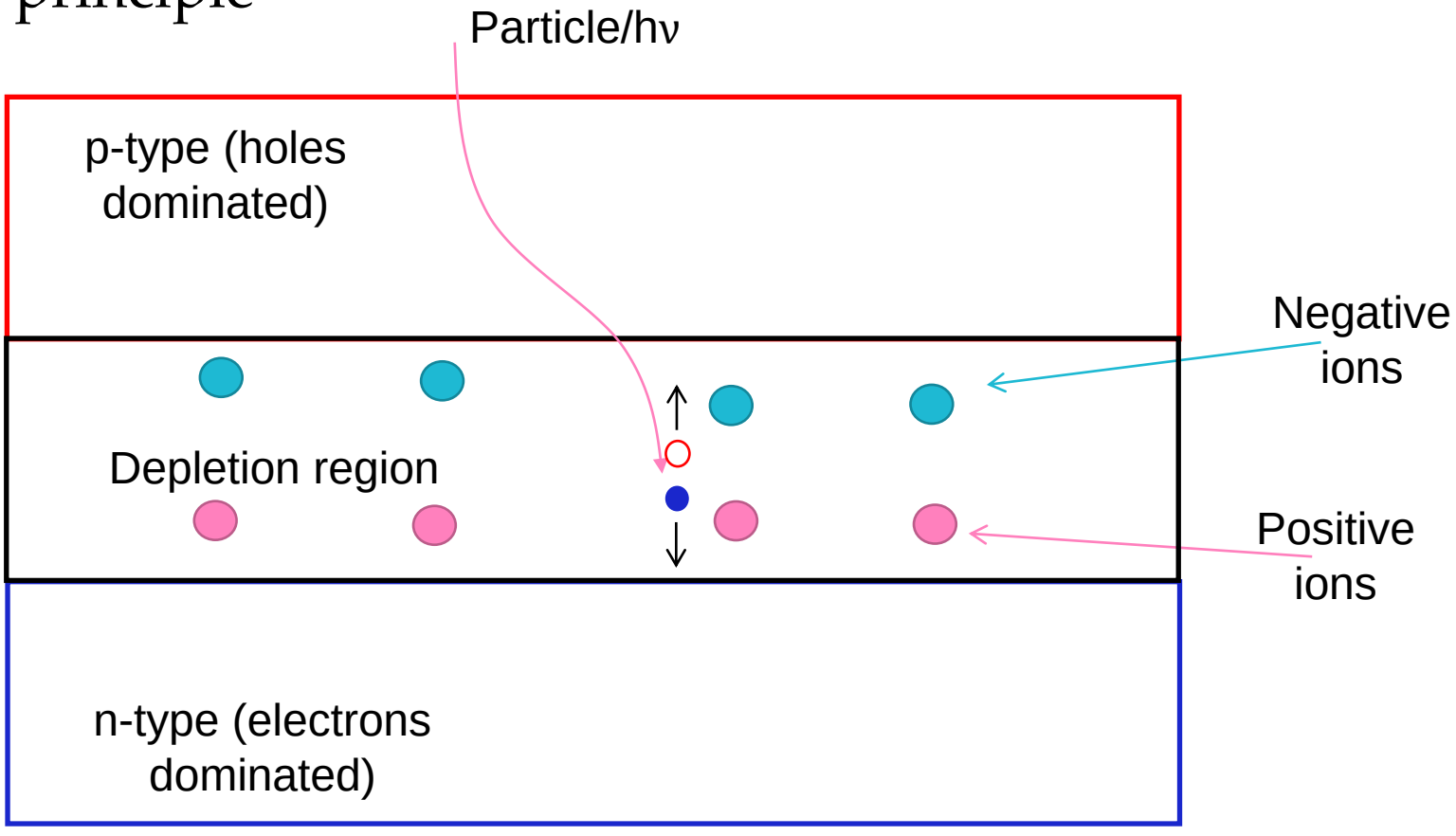
SEMICONDUCTOR DETECTORS.

ZHARKOVA ALINA

Basic principle



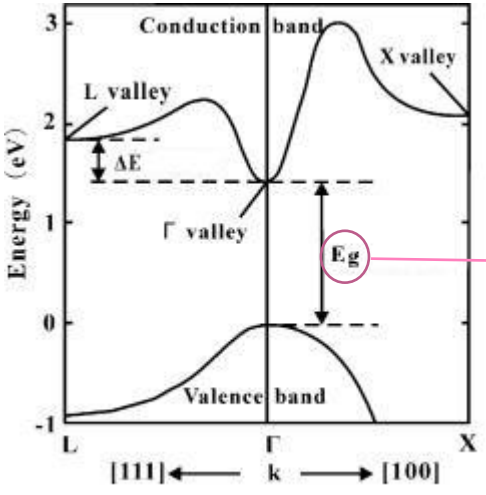
Semiconductor materials

•In contrast to isolators and conductors, conductivity in semiconductor materials could be changed because of insignificant external impacts.

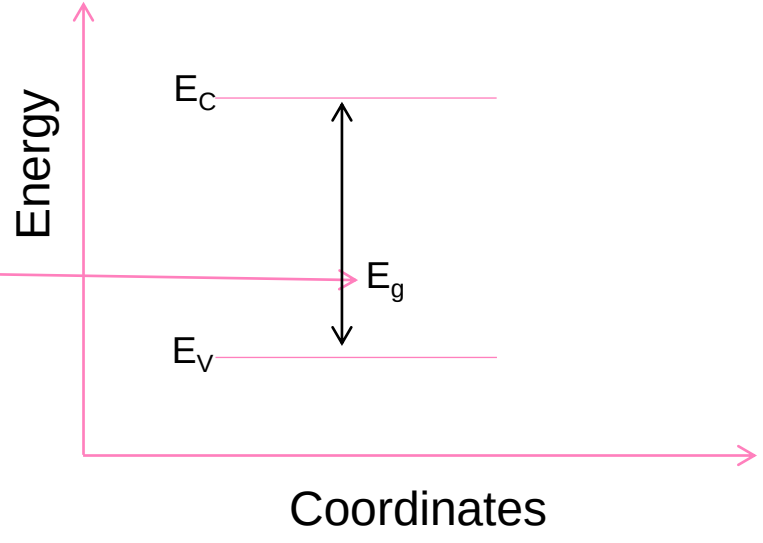
Conductors: Free carriers.
Isolator: Carriers belong to a particular atom.
Semiconductor: Almost all carriers belong to a particular atom, but there are some free carriers, and these carriers determine conductivity.

Band gap concept

Reciprocal space



Real space

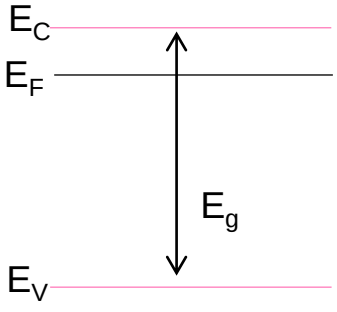


Electrons and holes. Fermi energy

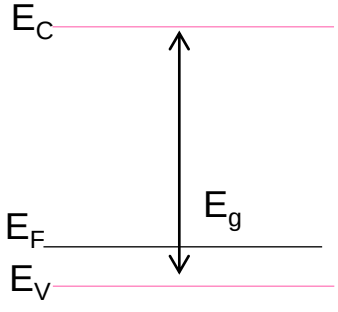
•Holes and electrons in periodic field of semiconductor are quasiparticles

•Fermi “level” does not exist physically, it is used for a mathematical description of the charge carrier energy distribution.

n-type
(electrons dominated)



p-type
(holes dominated)



$$F(\varepsilon, T) = \frac{1}{\exp\left(\frac{\varepsilon - E_F}{kT}\right) + 1}.$$

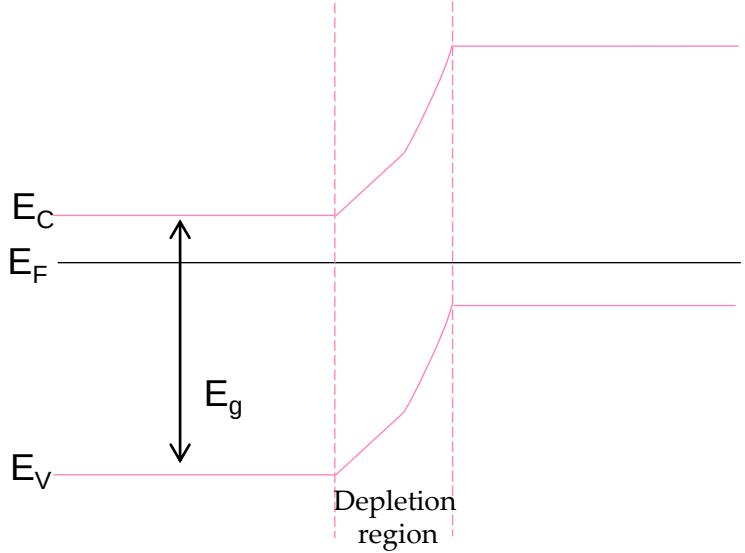
Poisson's equation

•Width of depletion region depends on doping and material parameters

$$W = \sqrt{\frac{2\varepsilon_S \varepsilon_0 (U+\varphi_K)}{qN_A}},$$

•The width of depletion region is boundary condition for solving the Poisson equation

$$div(\varepsilon \nabla \phi) = -\frac{q}{\varepsilon_0}(p - n + N_d - N_a),$$

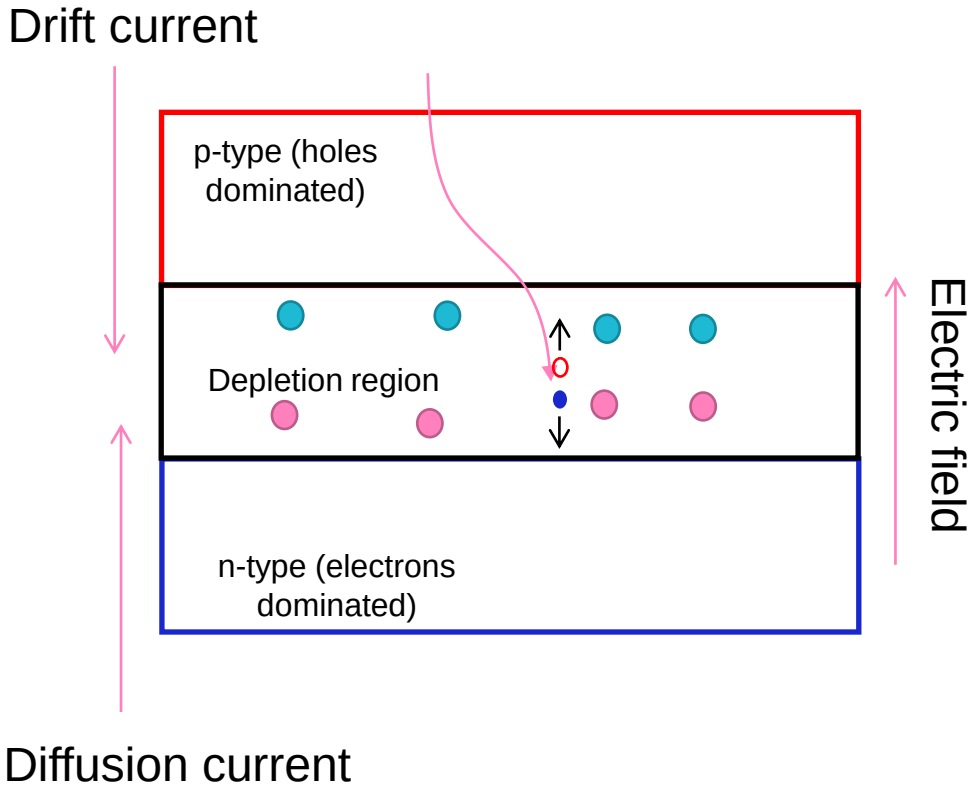


Continuity equation

$$\frac{\partial n}{\partial t} = D_e \frac{\partial^2 n}{\partial x^2} + \mu_e E_x \frac{\partial n}{\partial x} + G - R$$

Diffusion current

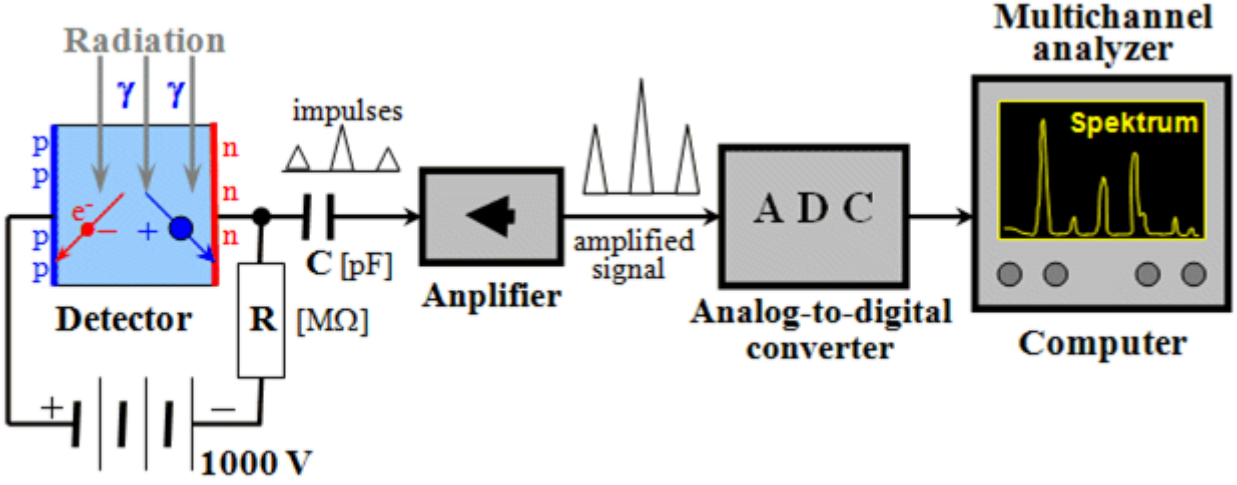
Drift current



Application in particle physics

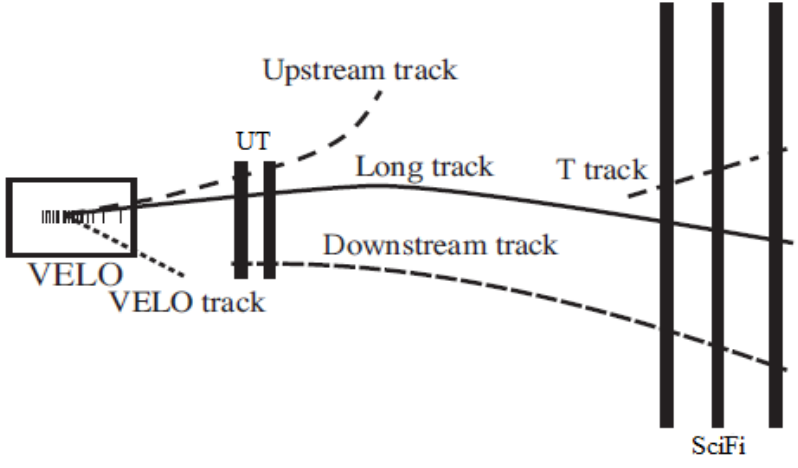
- As spectrometry detector
- As particle counter
- As photodetector

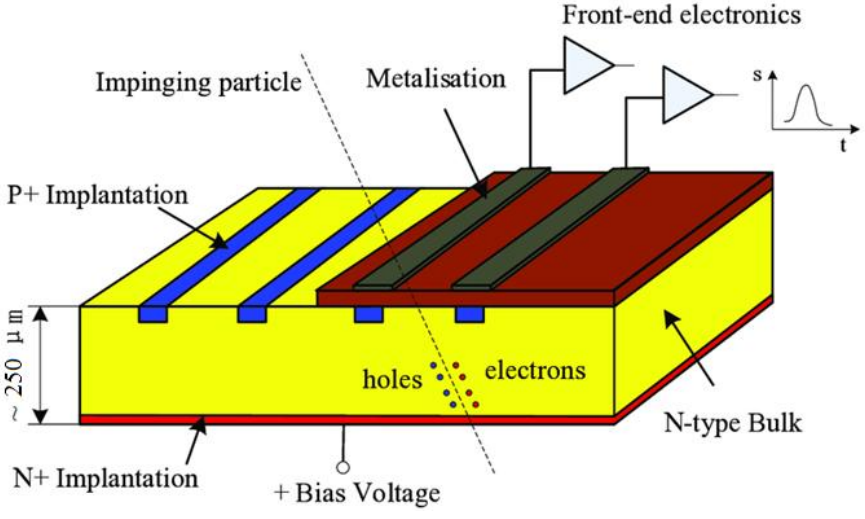
Spectrometer application



https://astronuclphysics.info/DetekceSpektrometrie.htm

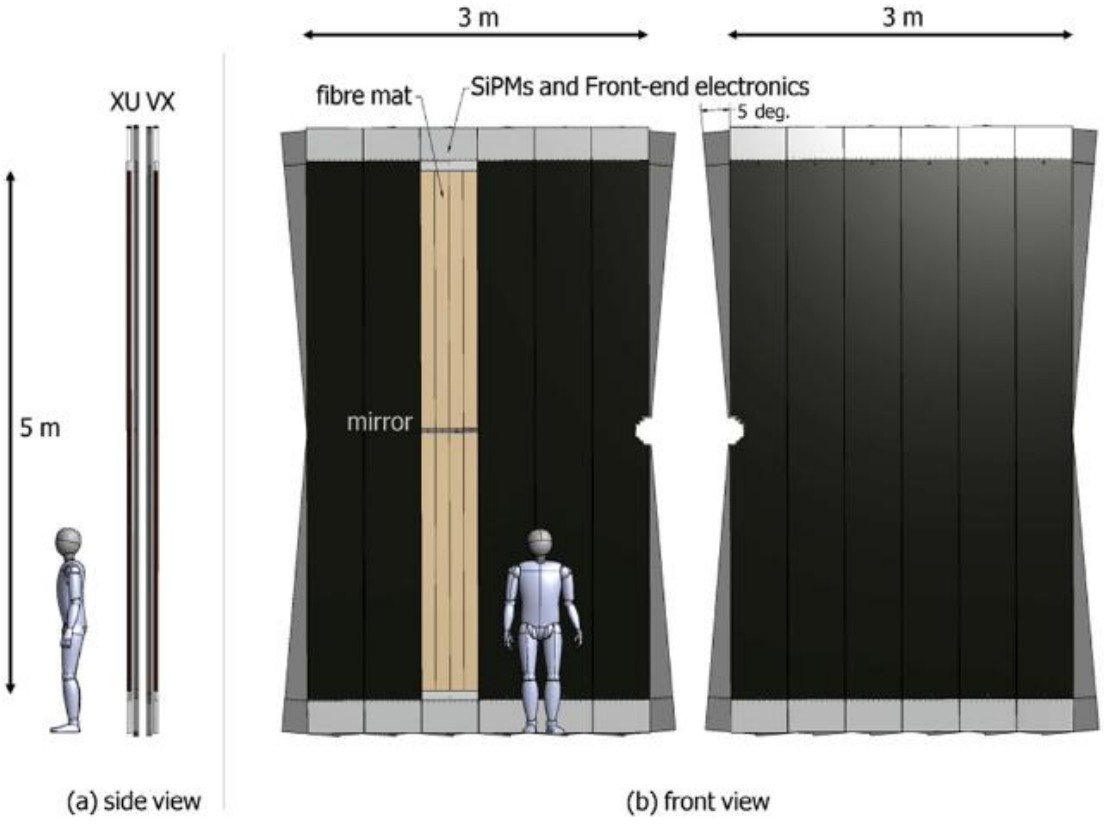
Example. Counter application in Tracking system. (LHCb)





LHCb Collaboration et al. LHCb tracker upgrade technical design report. – 2014. – №. CERN-LHCC-2014-001.

Example. Photodetector application in Sci-Fi.(LHCb)



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Semiconductor detectors

High time resolution
Small sizes, so spatial resolution could be also high
High and low voltage
Could work with and without scintillators
Spectrally operates at low energies
High price